U. S. DEPARTMENT OF AGRICULTURE

Forest Service

SOUTHEASTERN FOREST EXPERIMENT STATION

Asheville, N. C.
Technical Note No. 66 November 5, 1946

PINE PULPWOOD PRODUCTION

A Study of Hand and Power Methods

By

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INTRODUCTION

The use of power equipment for pine pulpwood production in the Southern Appalachians is rather recent. Consequently there is a lack of specific time and cost data for such operations in the region. To provide information for the pulpwood operator, a cooperative time and cost study was undertaken by the Champion Fibre Company, of Canton, N. C., and the Southeastern Forest Experiment Station, of Asheville, N. C. This technical note summarizes the results of the project. In it are compared the relative costs of producing a unit of wood for hand and power methods. The vital importance of delay time as a factor lowering efficiency is also demonstrated.

Most of the data are summarized graphically in figures 1 - 6. These figures and their significance will be discussed in detail, following a brief description of the location and other conditions of the study.

STUDY AREA AND CONDITIONS

Most of the field data were collected in the vicinity of Skyland, N. C. on land owned by the Biltmore Estate. The topography on the area was gently rolling, with an occasional short slope as steep as 30 percent. Most of the stands cut were of the old-field type and averaged 40 years of age. Clear-cutting was the rule and volumes ranged from 15 to 35 cords per acre. The bulk of the cut consists of Virginia pine. It is estimated that less than a third of the total cut to date is from shortleaf and pitch pines.

Following a work plan developed by the Station, most of the field observations were recorded by the cooperating company's personnel, and were collected from February through May 1946. Data were summarized and analyzed by the Station's personnel. Regression analyses were made for the felling, bucking, and skidding operations. All data given apply to clear-cutting operations only. No allowance has been made in the data, curves, or discussion for the fact that the power equipment was operated by "green" hourly labor, whereas the hand equipment was operated by seasoned contract labor. Nor were supervisory costs included in any case.

The types of hand and power tools studied include axe, bow saw, crosscut saw, chain saw and circular saw, with accompanying crews as described. Comparisons of hand methods of felling included one man with an axe (A_1), one man with a bow saw (B_1), two men with a bow saw (B_2), and two men with a crosscut (C_2). Hand bucking included one man with a bow saw (B_1), two men with a bow saw (B_2), and two men with a crosscut saw (C_2). Power felling was done with chain saws using a 3-man crew (Ch_3), and a 4-man crew (Ch_4); also with a circle saw of the buggy type using a 4-man crew (Cr_4). Power bucking tools included the above-mentioned chain saws and circle saw, except that in the latter case a 3-man crew (Cr_3) was found most efficient. Various combinations of tools and crew size were graphically tested, but only the most promising ones are discussed in this paper.

SUMMARY

Graphs in figure 1 show the man-hours required to fell, trim and buck a unit of shortleaf or pitch pine pulpwood by tree sizes for the various methods studied. Those curves shown in figure 2 portray the same type of information expressed in dollars per unit instead of man-hours. Production cost for Virginia pine ran 20 to 60 cents more per unit than shortleaf, with the 20 cents applying to largest diameters and the 60 cents to the smallest (5 inches) shown in figure 2 B. Part A, the upper half of both figures, shows time or cost, excluding delay time, while the lower half shows the time or cost including delay time. Skidding and hauling times are not shown in these figures, since other factors such as distances transported are more important variables than d.b.h. (diameter breast high).

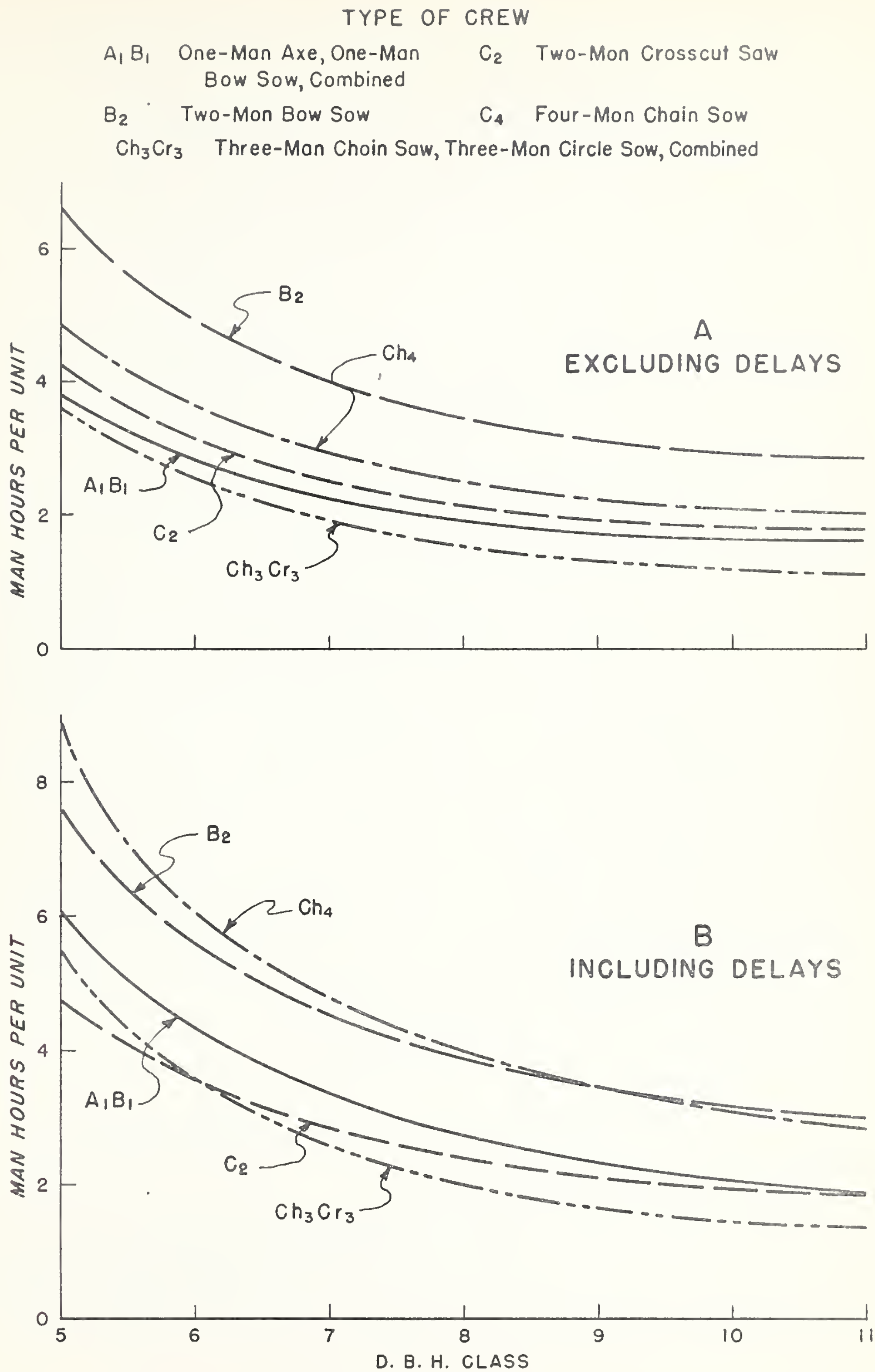

Figure 1.--Production time per unit (160 cu. ft.) for felling, trimming, and bucking.

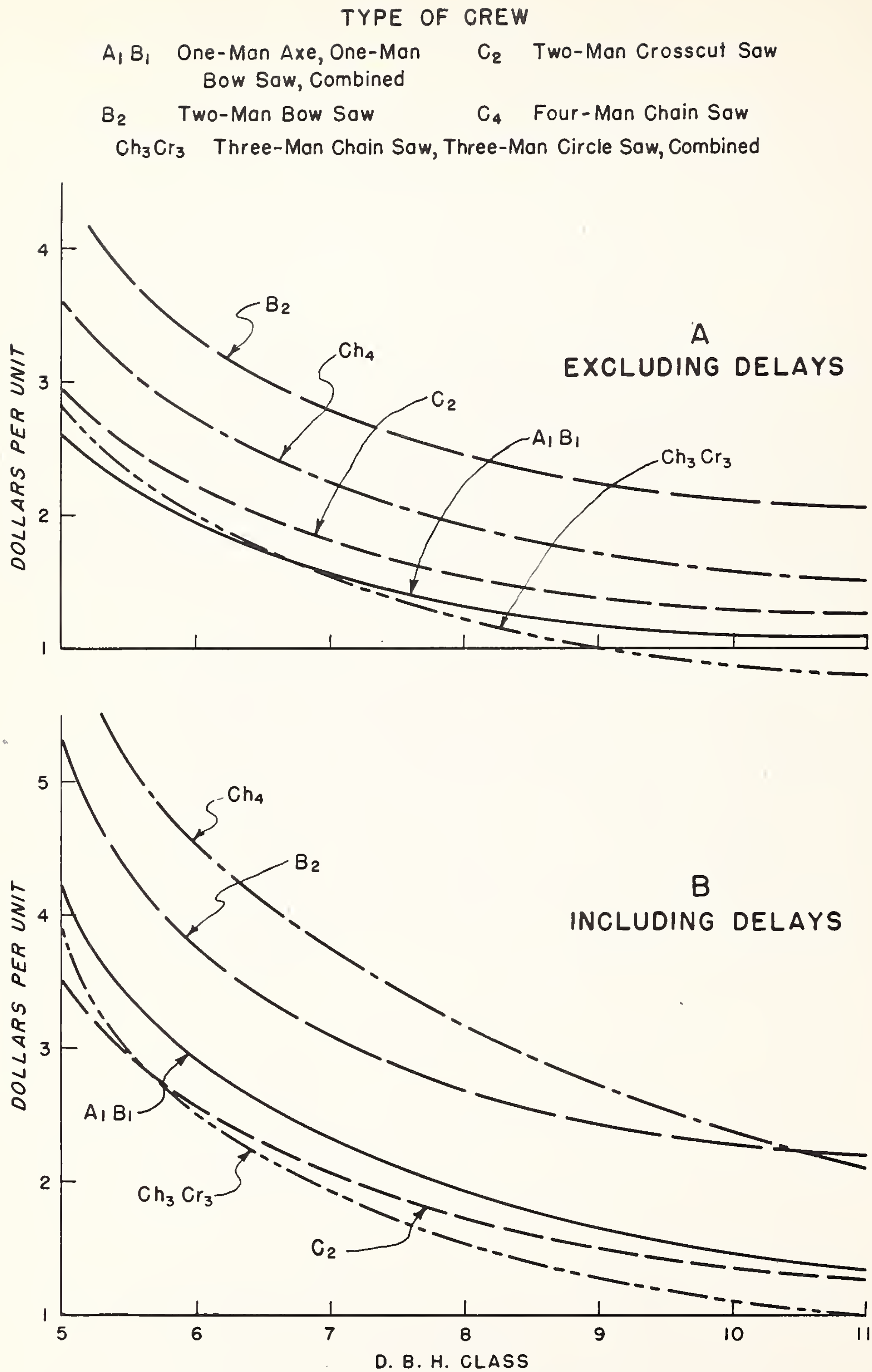

Figure 2.--Production cost per unit (160 cu. ft.) for felling, trimming, and bucking.

The importance of delay time is shown by the difference in curve location for each method in the A portion of each figure, compared with the B portion of the same figure. The set of curves shown in the A portion of each figure represents the time or cost theoretically possible if no delays occur - a very unlikely probability. The lower set of curves (B portion) represents the actual time or cost per unit including delays.

Delays required the following addition production time - averaged for all d.b.h. classes:

Crosscut saw (2 men)	5%
Bow saw (2 men)	10%
Axe and 1-man bow-saw combination	45%
Chain saw (4 men)	55%
Chain saw and circle saw combination (3 men each) . . .	30%

Delays appear to be independent of d.b.h. except for the trimming operation, where there is a slight increase accompanying increased d.b.h. While a reduction in delay time would improve the efficiency of every method studied, such a reduction is of special importance in the use of power equipment, where hourly rates are higher and the longest delays occur.

Hourly operating costs were computed for each of the methods studied. Tables showing how these costs were derived appear in the appendix. When dollars replace man-hours as an index of production, some changes in method efficiency occur. These differences can be readily observed by comparing figures 1 and 2. Excluding delays (part A of figures 1 and 2), the power combination Ch_3Cr_3 shows the lowest cost per unit in terms of man-hours for all diameters. But on a dollar basis, the axe and 1-man bow-saw combination emerges as the most efficient method of production - for trees under 7 inches d.b.h. When delay time is included, however, the 3-man chain and 3-man circle-saw combination maintains its position as the cheapest method of production for trees 6 inches d.b.h. and over. But the power combination's margin of profit is narrower on a dollar basis than on a man-hour basis because of the higher hourly rate for the power equipment.

DETAILED ANALYSES OF THE VARIOUS OPERATIONS STUDIED

The 3-man chain saw (see figure 3, A, B) was the most efficient felling method studied, both excluding and including delay time. Although the best power-saw time averaged 25 percent faster than the best hand method, this increased efficiency would be somewhat offset by the

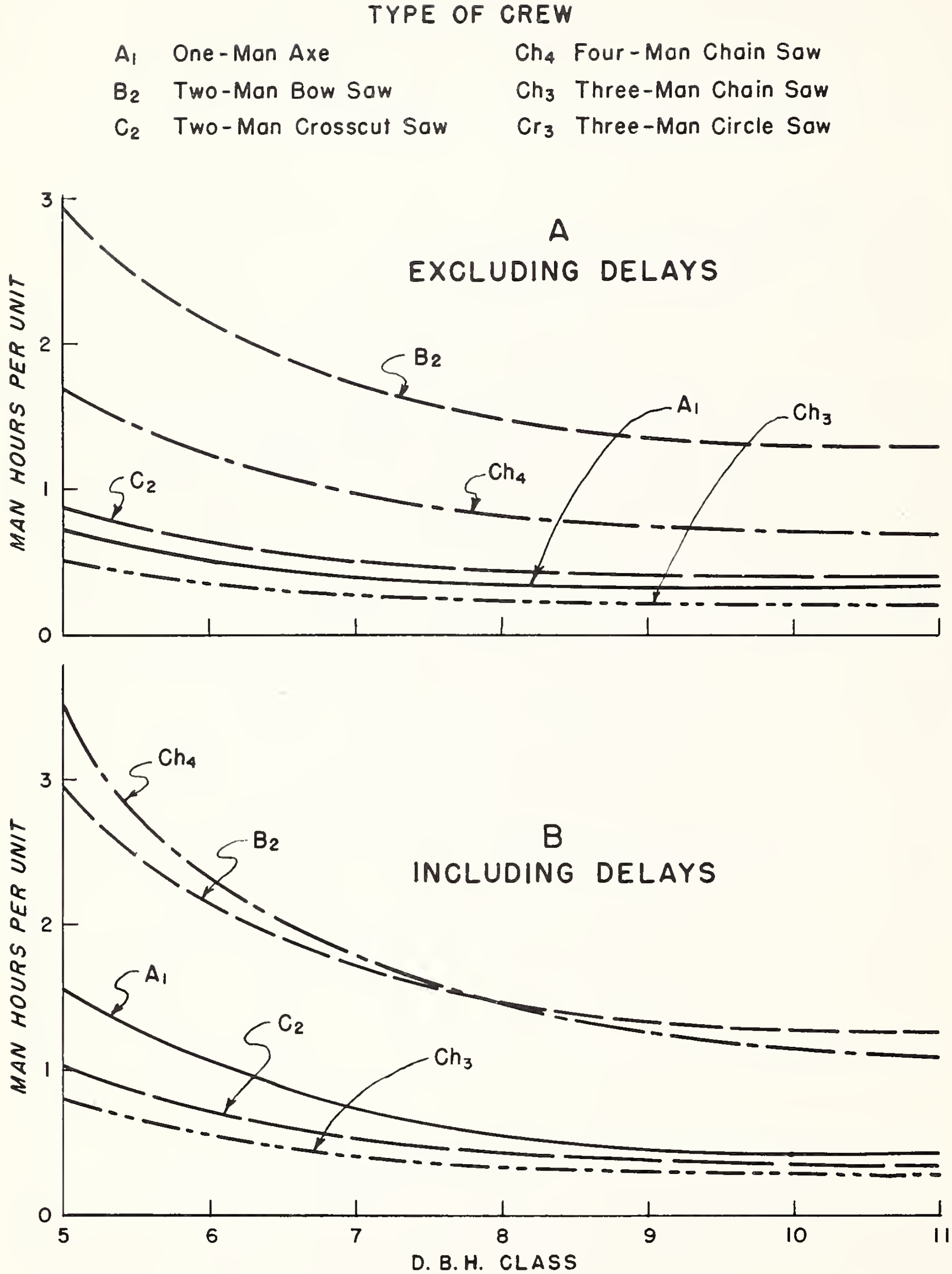

Figure 3.--Felling time per unit (160 cu. ft.)

added cost of power equipment. The 4-man chain crew, the 4-man circle-saw crew, and the 2-man bow-saw crew were very inefficient when compared with other methods. The felling rate shown for the 3-man chain saw (figure 3 A) closely approximates that given by Niederhoff[1/] for inexperienced workers using a circular saw. On the other hand, none of our study results begin to approach his rate of 7 units per hour for the experienced tree feller.

The axe method of felling appears to be very economical until delay time is included, whereupon it is superseded by the crosscut saw. Then too, the axe-cut butts were not considered acceptable until the war. If they continue to be acceptable, the axe method in combination with the 1-man bow-saw would be a good 1-man method for the farmer or other small operator.

Trimming or Limbing

Trimming, as shown in figure 4, A and B portions, also varies by d.b.h. class. There is also a significant difference in trimming time required for Virginia pine as compared with the shortleaf and pitch combination. This extra trim time for Virginia pine ranged from 0.2 man-hour per unit in 11-inch trees to 1 man-hour in 4-inch trees. Delay time for trimming only was found to be correlated with d.b.h.

All trimming was done by one man using an axe. This appears to be the most satisfactory method in common use.

Bucking

In the power system most commonly used, (Ch_3Cr_3), skidding usually followed limbing, and bucking was accomplished at the landings. With most of the hand methods, however, bucking in the woods followed limbing, and no skidding was done. The bucked wood was ricked or thrown in a pile and later loaded onto trucks.

As a by-product of the study, ricking was found to be an expensive and unnecessary operation. An average of 1 man-hour was required to rick a unit of wood.

Again the 2-man bow saw and the 4-man chain saw were found to be the least efficient.

[1/] Niederhoff, C. H. Power felling equipment. Pulp and Paper Journal. Sept. 15, 1946.

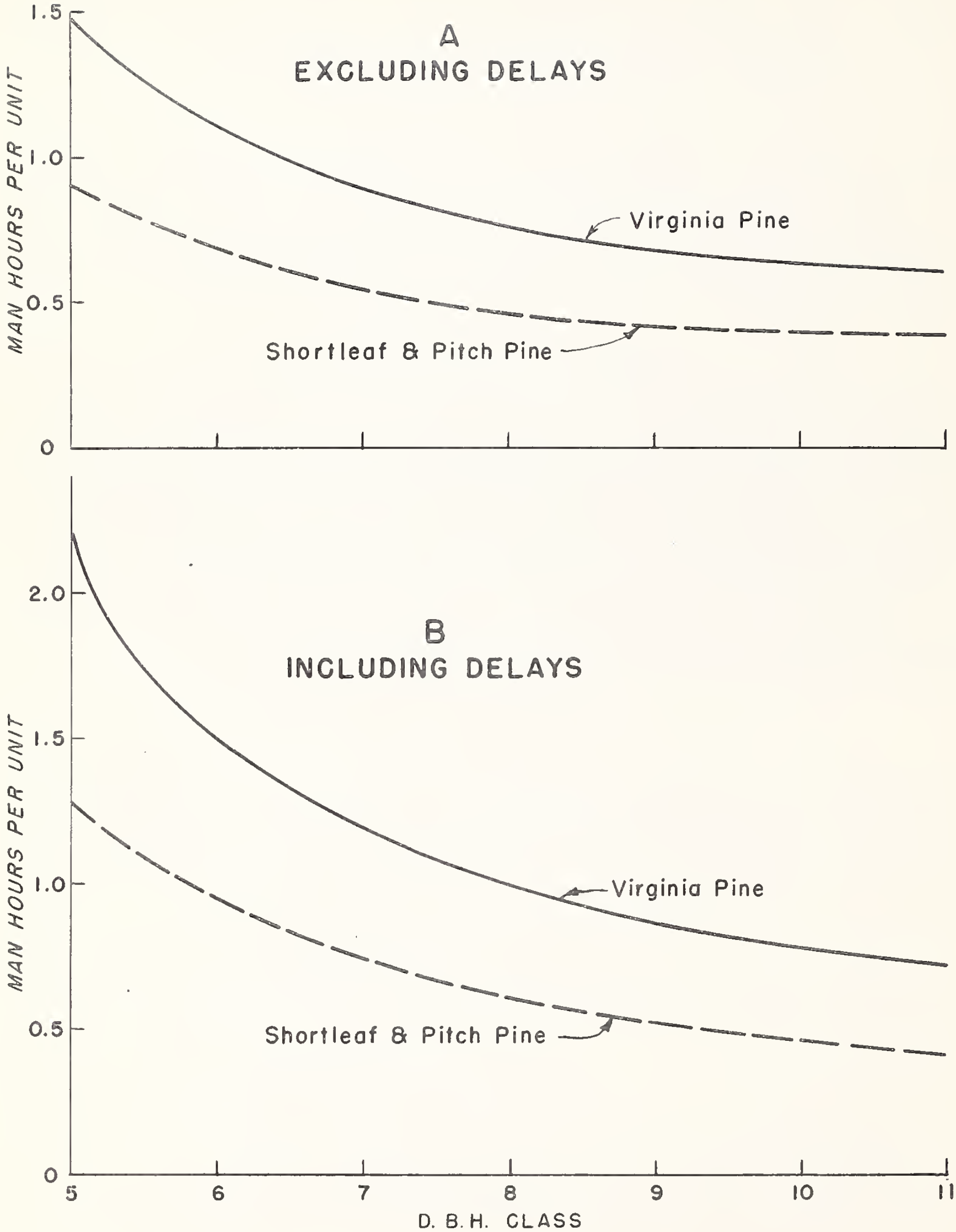

Figure 4.--Trimming time per unit (160 cu. ft.) for one man with axe.

Because of the small difference in production time between the circle saw (Cr_3) and the other methods shown in figure 5 (part A), the bucking times were compared for the same number of trees of each diameter class for all methods. This analysis (based on productive time only) indicated that the 3-man circle saw method was:

11 percent faster than the 4-man chain saw.
11 percent faster than the 1-man bow saw.
19 percent faster than the 2-man crosscut saw.
40 percent faster than the 2-man bow saw.

It was thought that the experience gained over a period of 10 weeks in operating the circle saw had reduced the average bucking time. A subsequent time check showed only a slight improvement in bucking time. On the other hand, a considerable increase in delay time was observed. The increased delay time was due primarily to organizational difficulties, with none of it being chargeable to equipment failure.

The bucking operation accounted for most of the decreased production time per unit when this analysis is compared with past reports of unmechanized operations. Even with delay time included, the three most efficient methods studied all produced wood at faster rates than those shown in Occasional Paper No. 58[2/] or those given by Downs.[3/] The 3-man circle-saw crew bucked wood at approximately the same rate as that shown by Niederhoff.[4/]

Skidding

The most important variables observed in relation to skidding time were found to be distance and number of trees skidded per trip. Neither d.b.h. nor cubic feet per load were significantly important variables. The average load consisted of 2 trees amounting to 11.7 cubic feet. Apparently, the only reason for skidding time not increasing more rapidly as the skidding distance increased was that

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2/ Occasional Paper No. 58. Southern Forest Experiment Station. December 1936.

3/ Downs, A. A. The influences of silvicultural practice on the costs of felling and bucking loblolly pine pulpwood. Jour. Forestry 40: 37-44. January 1942.

4/ See footnote No. 1, page 7.

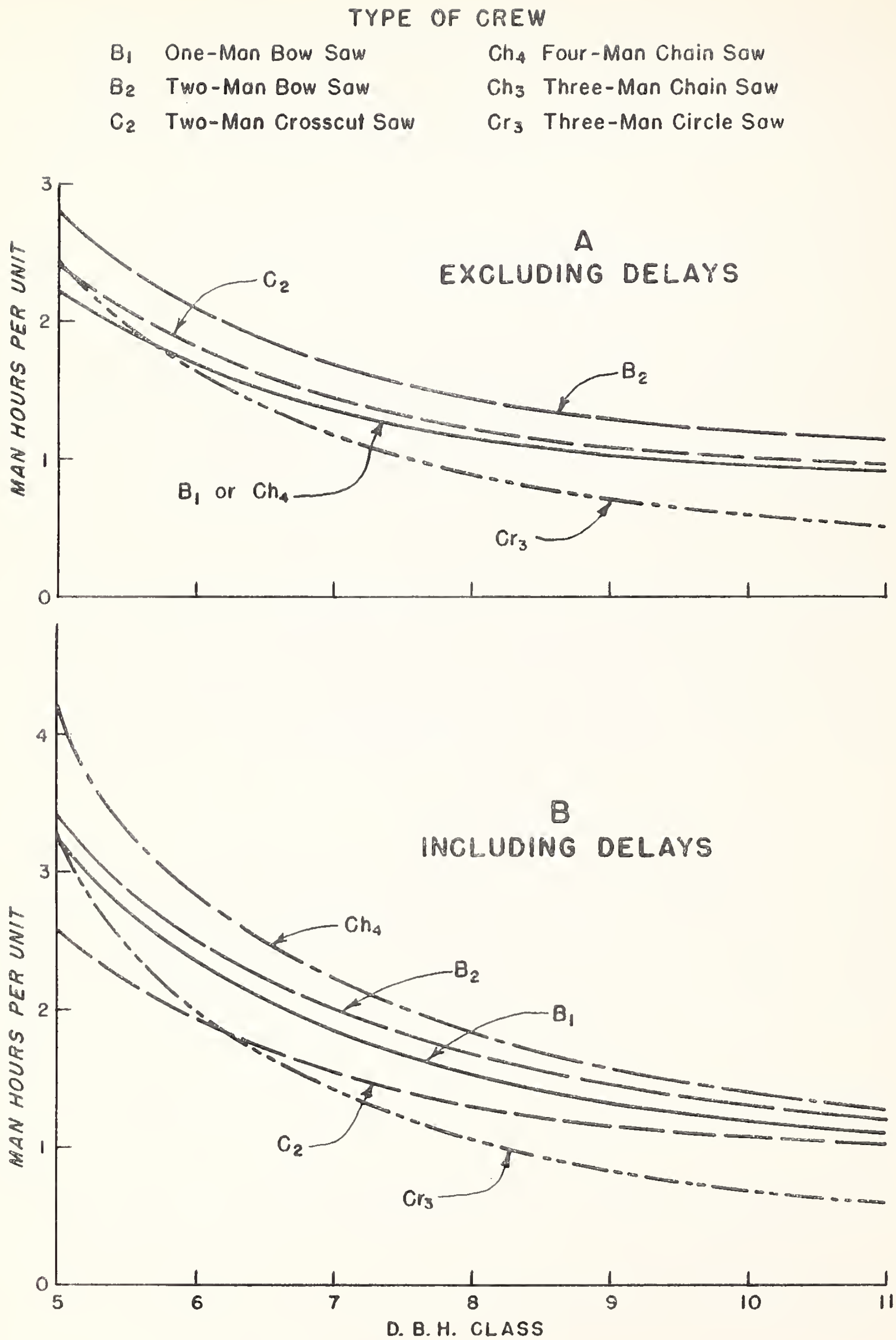

Figure 5.--Bucking time per unit (160 cu. ft.).

capacity loads were not hauled. An increase of 50 percent in the average size load would likely show a rapid increase in both travel and delay time for distances over 300 feet. Using the average 2-tree load curve, skidding time increases at the rate of 0.2 crew-hour (horse and driver) per 100 feet of distance hauled, within the range studied (100 to 800 feet). Thus skidding time, including delays, will add from $1\frac{1}{4}$ to $2\frac{1}{2}$ hours (see figure 6) to the average production time for each method shown in figure 1, part B, and from $1.20 to $2.40 to the costs shown in figure 2, part B.

Costs

Hourly rates were computed for the various operating methods studied. These rates were based on the best available data and were checked against similar costs wherever possible. Identical hourly rates (of 68 cents) were used for the one-man crews whether an axe or a bow saw was the tool. Possibly slight differences in rates could be computed, but the differences would be insignificant in relation to total costs. (See table 4, Appendix.) The same rates were applied to the 2-man bow and the 2-man crosscut crews (72 cents per hour). All power equipment rates were computed separately. An hourly rate for skidding was also computed. Derivations of these rates can be found in the attached appendix.

When the dollar cost per unit is compared with the hourly cost per unit of production, some minor changes in efficiency of the various methods occur. For example, in part A of both figures 1 and 2, where delays have been excluded, the power combination Ch_3Cr_3 showed the lowest cost per unit in terms of man-hours for all d.b.h. classes. However, on a dollar basis, the axe and 1-man bow-saw combination emerges as the lowest-cost method for trees under 7 inches d.b.h. With delay time included, the Ch_3Cr_3 power combination remains the most economical method of production studied for trees 6 inches d.b.h. and above. But the margin between this power combination and the most efficient hand method is somewhat narrower than when man-hours were the basis of comparison.

Skidding costs are not included in figure 2 for the same reason that they were omitted from figure 1, namely, because the important variables are not related to tree d.b.h. As indicated before, these variables are distance skidded and number of trees hauled per trip. The cost in dollars per unit for the average 2-tree skidding trip is as follows:

100 feet	$0.90
300 feet	$1.40
500 feet	$1.85
700 feet	$2.30

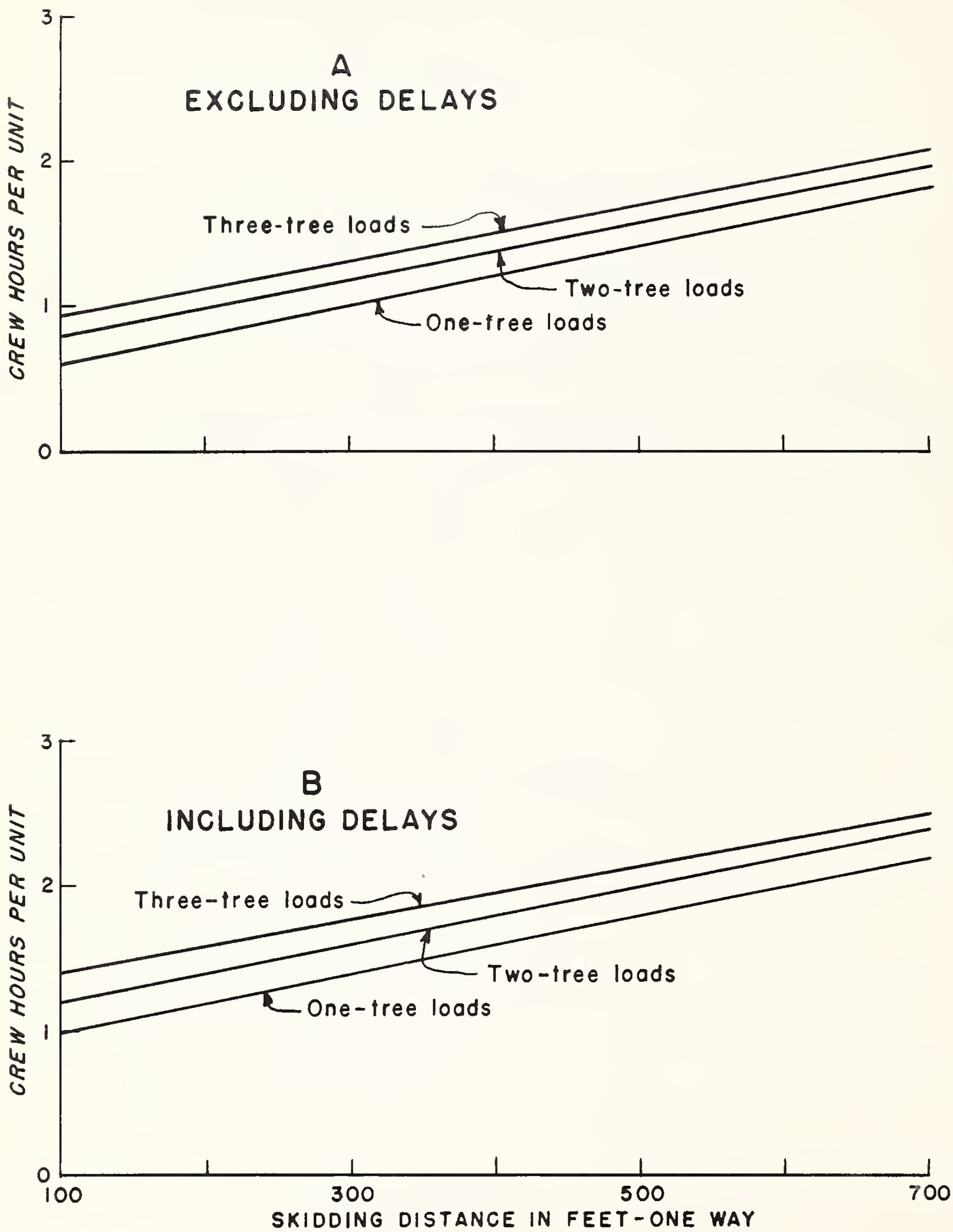

Figure 6.--Skidding time per unit (100 cu. ft.) for driver and one horse.

For other load sizes (1 or 3 trees per trip) add or subtract 20 cents respectively.

Supervisory costs were not included in the man-hour rates because the hand methods were all contract jobs, whereas the power methods were all supervised. Of course, the machines could be charged a supervisory cost which would probably offset any advantage the power methods showed. Due to the wide range of supervisory costs it seemed advisable to eliminate this variable and make the comparisons independent of this item.

CONCLUSIONS

Reducing delays to a minimum is of paramount importance. Delays increased the cost of production in even the most efficient method studied (Ch_3Cr_3) by an average of 25 percent. Delays were responsible for replacing the theoretically highly efficient hand combination (A_1B_1) by a somewhat less efficient method (C_2). They were also responsible for increasing the 4-man chain saw costs some 60 percent. None of the delays observed was due to equipment failure. Most delays were due to improper organization of work, which resulted in abnormally long rest periods. For example, the circle-saw bucking crew frequently waited 20 minutes or more between operations while a new deck of logs was being placed. A five-minute delay for rest could be considered adequate. The 20-minute delay could have been reduced by the addition of an extra landing and by adding another skidding crew. Proper integration of work is undoubtedly the key to successful use of power equipment. A corollary requirement is the proper training of the crews using such equipment.

As woods mechanization continues to expand, further studies of integration need be made. These can probably be done best by each operator, since operating conditions vary so widely in the mountains. Thus, wheel type power saws may be impossible to use in rough terrain and yet be ideal at landings or in flat land where there is little underbrush. Or skidding in tree lengths may be the most productive method up to certain maximum slopes, beyond which it would probably be more profitable to cut the tree into bolts and "ball hoot" the bolts to concentration points.

Present studies indicate that only a large operator can afford the investment required for a well-mechanized operation. The reason is that only in cases of large total cuts can the cost of power equipment be reasonably depreciated. Thus a farmer cutting only 100 cords of wood annually can ill afford the $350 investment in a power saw when his maximum annual savings would probably not exceed $25.00.

APPENDIX

The following tables of hourly costs for the various operating methods studied show in detail the manner in which these rates were derived. Although they were field checked for such items as hourly consumption of gas and oil, time required for filing saws and similar data, they should not be regarded as absolute. One of the large items, that concerning depreciation, is subject to considerable judgment and interpretation. For instance, one company estimates the life of a power saw at two years, whereas another plans to operate a similar saw for as long as five years; the difference being that the one company expects to spend little on maintenance or repair, whereas the other will spend considerable for these items in order to prolong the useful life of the saw. It is believed that, with reasonable care and proper maintenance, a 3-year period of depreciation would be a good average. Because of the newness of the equipment, only meager information regarding repair costs was obtained in this study. Practically no breakdowns occurred and consequently the cost figures used are only estimates based upon others' experience.

If power saw operators are paid a different wage from that received by other woods workers, this cost item should be adjusted accordingly. It might benefit the owner of such power equipment to pay higher rates to power equipment operators in order to attract and hold more skillful workers for such jobs.

The final table, Miscellaneous Time, is given only for general information. Close approximations of hauling costs can be calculated by using the time data from table 6 in conjunction with appropriate hourly operating costs for trucks. It is presumed that each operator or company knows or can secure suitable truck operating rates. No attempt was made in this study to obtain such rates, since the wood was hauled by contract.

Table 1.--Chain saws and crews

INVESTMENT

Delivery cost of the 3-man saw at $710.00
Delivery cost of the 4-man saw at $650.00
Residual value at the end of 3 years is zero
Average annual investment of 3-man chain saw at $236.67
Average annual investment of 4-man chain saw at $216.67

HOURLY COSTS:

	3-man crew	4-man crew
Fixed		
Interest, taxes and insurance at 10% of annual investment divided by 1600 hours (200 days at 8 hrs.)	$ .015	$ .013
Depreciation (total cost divided by 1800 hrs.)	.148	.135
Repairs (including labor)[1]	.10	.10
	$ .263	$ .248
Operating		
Gasoline at 1/4 gal. per hour at 25¢[1]	$ .06	$ .06
Oil for gas and chain lubrication, .05 gal. at 60¢[1]	.03	.03
Filing chain at $1.50 each, at 16 hours[1]	.09	.09
Crew, at 60¢ per hour	1.80	2.40
Payroll taxes (Soc. Sec. at 1%, Unemployment at 2.8%, Ind. Compensation at 6.2% = 10%)	.18	.24
Total operating cost	$ 2.16	$ 2.82
Total fixed cost	.25	.25
	$ 2.41	$ 3.07
Man-hour cost	$ .80	$ .77

[1] Based on data from F. C. Becker's report, "An Economic Comparison of Power Chain Saws and Manual Cross-cut Saws," Forestry Relations Department, Tennessee Valley Authority, August 1945.

Table 2.--Circular saw and crews

INVESTMENT

Delivered cost, $355.00
Residual value at end of 3 years = 0
Average annual investment = $355 ÷ 3 = $118.33

HOURLY COSTS:

	3-man crew
Fixed	
Interest, taxes, and insurance at 10% of average annual investment ÷ 1600 hours	$ .01
Depreciation (3 yrs. at 1600 hrs. = 4800 hrs.)	.07
Repairs (including labor)[1]	.03
Total fixed cost	$ .11
Operating	
Gasoline at 3/8 gal. per hr. at 25¢	$ .09
Oil, .03 gal. at 60¢	.02
Filing at 1/2 hour per day x 60¢	.04
Crew, 3 men at 60¢	1.80
Payroll taxes (Soc. Sec. at 1%, Unemployment at 2.8%, Ind. Compensation at 6.2% = 10%)	.18
Total operating cost	$ 2.13
Total fixed cost	.11
	$ 2.24
Man-hour cost	$ .75

[1] Estimated.

Table 3.—Two-man crosscut or two-man bow-saw crews

INVESTMENT

Estimated Delivered Cost (2 saws at $9.50, 2 axes at $3.50, 1 pair wedges at $2.00, 1 hammer at $3.00; total $31.00). Average life 1 year.

Average annual investment — $31.00

HOURLY COSTS:

	2-man crew
Fixed	
Interest, taxes, insurance, at 1/1600 of average annual investment	$ .02
Depreciation at 1/1600 average annual investment	.02
Maintenance[1]	.07
Total fixed cost	$ .11
Operating	
Labor, 2 men at 60¢	$ 1.20
Payroll taxes, and insurance at 10%	.12
Total operating cost	$ 1.32
Total fixed cost	.11
	$ 1.43
Man-hour cost	$ .72

[1] From F. C. Becker's report, "An Economic Comparison of Power Chain Saws and Manual Cross-cut Saws," Forestry Relations Department, Tennessee Valley Authority, August 1945.

Table 4.--One-man axe crew or one-man bow-saw crew

INVESTMENT	Axe	Bow saw
Axes, 2 at $4.00	$ 8.00	
Axe handles, 2 at 75¢	1.50	
Files, 1 every two weeks at 20¢	5.20	$ 5.20
Bow saw and blades[1]		8.20
Total annual investment	$ 14.70	$ 13.40
HOURLY COSTS:		
Fixed		
Depreciation at 1/1600 annual investment	$ .01	$ .01
Maintenance - filing	.01	.02
Total fixed cost	$ .02	$ .03
Operating		
Labor, 1 man at 60¢	$ .60	$ .60
Payroll, taxes, insurance, etc. at 10%	.06	.06
Total operating cost	$ .66	$ .66
Total fixed cost	.02	.03
Man-hour cost	$ .68	$ .69

[1] Estimated bow-saw cost: frame $5.00; 8 blades totaling $3.20

Table 5.--Skidding crew

INVESTMENT

Horse, original cost $250, resale value at end of 5 years $50. Net annual cost = $200 ÷ 5 years	$ 40.00
Harness, $60 ÷ 6 years	10.00
Shoeing	5.00
Total average annual investment	$ 55.00

HOURLY COSTS:

Fixed

Interest, taxes, and insurance at 10% of average annual investment ($5.50 ÷ 1600 hours)	--
Tools and supplies[1]	$ .03
Depreciation at $55 ÷ 1600 hours	.03
Feed at $10 per week ÷ 40 hours	.25
Total hourly costs	$ .31

Operating

Wages, teamster at 75¢	$ .75
Taxes, etc., at 10%	.075
Total operating costs	.825
Total fixed costs	.314
Total hourly costs	$ 1.139
Round off to	1.15

[1] Estimated for maul, tongs, and/or chain.

Table 6.—Miscellaneous time

The times shown below are for ricking, loading and trucking.

Ricking

Averaged 1-man hour per unit, including 5 minutes delay time. This expensive operation was found to be unnecessary; hence it was discarded.

Loading and Unloading Trucks

Averaged 1.4 man-hours per unit, including delay time of 0.5 man-hour. Range was from 1.0 man-hour to 1.8 man-hours. Average load was 2 units. These average times and volumes are based on 8 loads. Unloading, from truck to open railroad car, averaged 0.5 man-hour per unit. Range was from 0.25 man-hour to 1.0 man-hour. Average of 4 loads timed.

Truck Travel Time

Type of Road	Loaded	Empty	Average
	..... speed in miles per hr......		
Woods, graded dirt	4	10	7
Gravel - poor alignment	10	15	12
Highway - good surface and alignment	20	30	25